

Toyota Testimony

By Bill Reinert

On

“Vehicle and Fuels Technology: Next Generation”

Before the

House Subcommittee on Energy and Air Quality

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Mr. Chairman and members of the committee, my name is Bill Reinert and I am National Manager, Advanced Technology for Toyota. I want to thank you for inviting Toyota to participate in this hearing and to provide our perspective on technology advancements on future automobiles within the mid-to-long term, with a particular emphasis on hybrid electric powertrains.

Toyota recognizes that the competing priorities of energy security, environmental concerns and emerging fuels may reshape the transportation fuels markets and, may one day, change customer perspectives on vehicle choice.

Today, within the United States, we can see emerging markets for biodiesel and the tremendous expansion of corn based ethanol production. We are also beginning to see previously overlooked hydrocarbon supplies, such as tar sands and very heavy crude products, making significant impacts on the market.

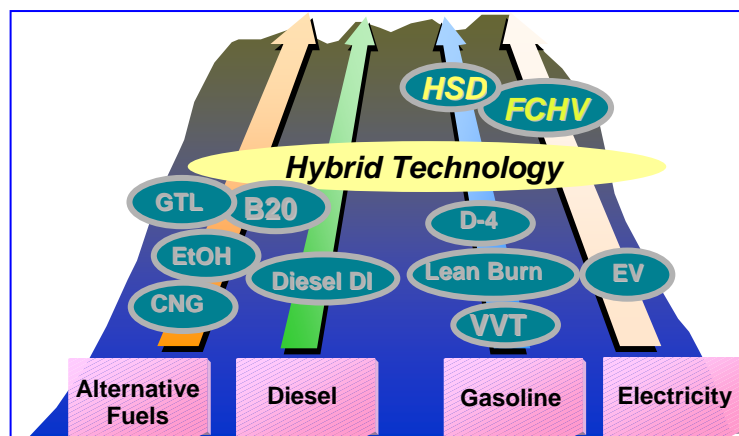
Fuels from abundant natural gas and coal reserves that are produced from the Fischer Tropish process may one day replace significant amounts of the petroleum we depend upon today.

We feel that our investments in hybrid development give us the opportunity to use these new fuels and maximize their benefits, especially during the time when production may be limited.

Expanded production of some alternative fuels may face land or water use limitations. Fuels produced by gas-to-liquids and coal-to-liquids may have water quality and CO<sub>2</sub> limitations. As alternative fuels replace increasing amounts of petroleum products, our consideration must also include methods to mitigate impacts to local eco-regions.

Advanced farming methods and the development of ethanol from cellulosic processes or from algae fed by CO<sub>2</sub> sequestered from coal fired power plants may eliminate many concerns. We are confident that in each of these instances technological developments can lead to sustainably-produced low-carbon or renewable fuels and reductions in oil imports.

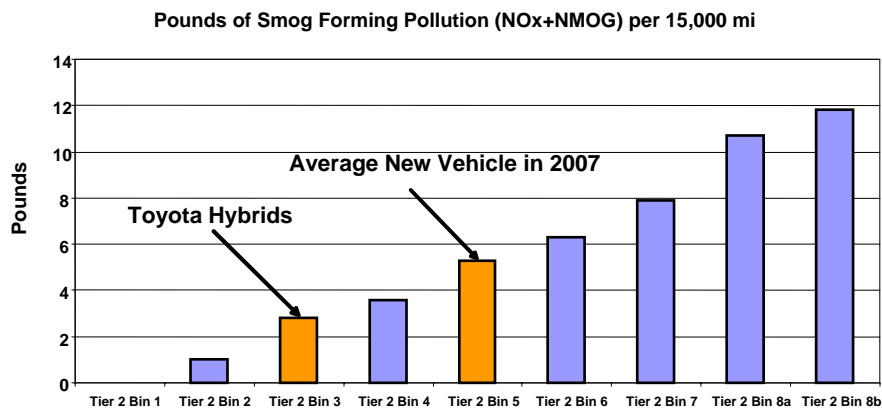
#### Sustainable Transportation



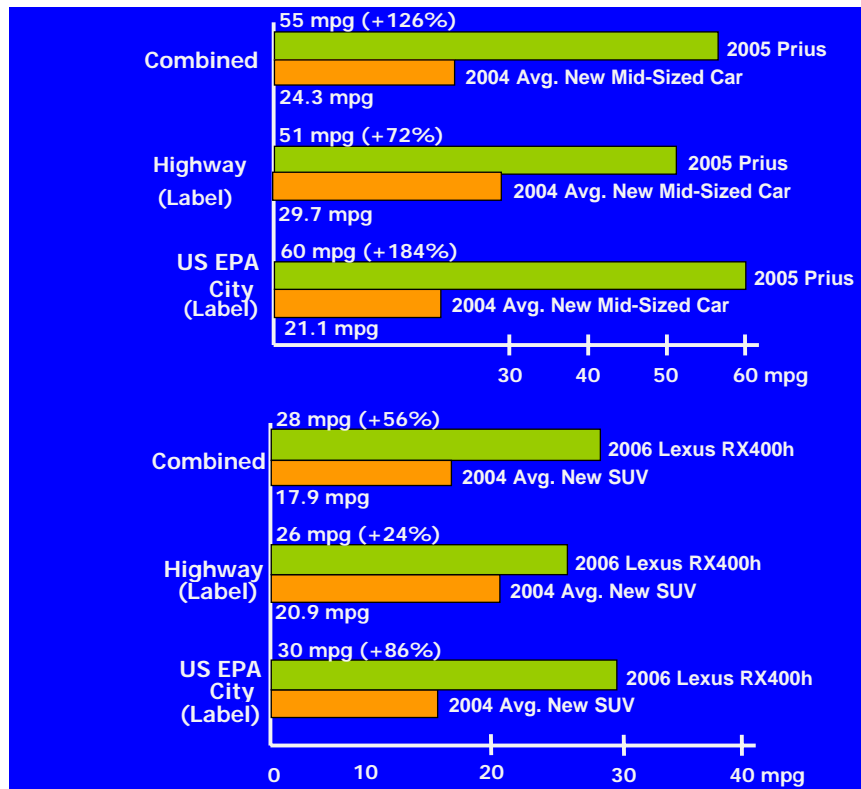
Toyota believes that there is no single fuel or technology that can solve all of society's transportation needs. Simply put, there is no single silver bullet. This is why Toyota is pursuing multiple technology paths in our continuing quest to reduce the impact of the automobile on society.

Key to our efforts is the ability to apply hybrid systems to any type of powertrain without constraint from the type of fuel or propulsion technology used. In other words, hybrids are a core technology for Toyota.

By combining battery energy storage with conventional powertrains, Toyota's Hybrid Synergy Drive system has the ability to greatly increase and, in some cases, double the efficiency of any propulsion system, while significantly reducing smog-forming emissions.

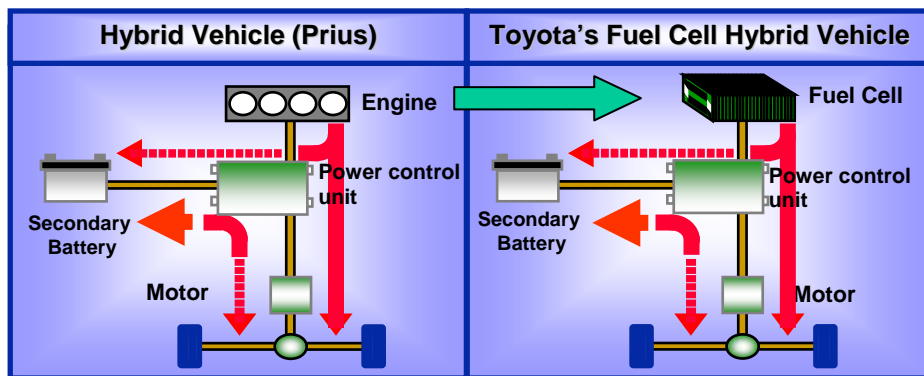


### Fuel Economy of Hybrids vs. Class Average



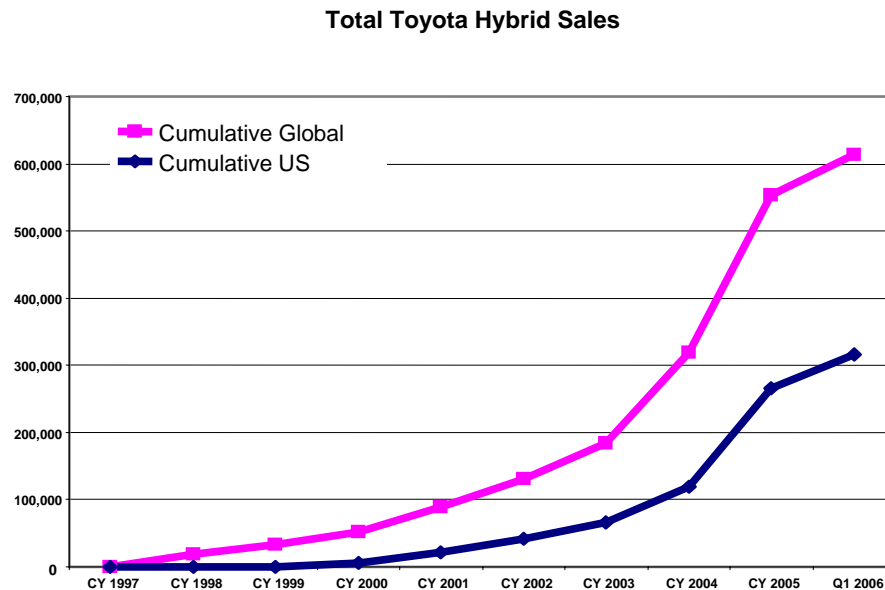
Some have characterized hybrid technology as an interim approach, a bridge to fuel cells. In our view, this underestimates the value of the hybrid system. The

### Hybrid Design Used in Fuel Cell Vehicle



fuel cell vehicles Toyota is now testing in the United States are hybrid designs and, in fact, use many of the same components that are found in today's Prius.

Since our introduction of the Prius in 1997, Toyota's cumulative global hybrid sales have exceeded 600,000 units. Of this total, over 300,000 have been sold in the United States.



Currently, Toyota has five different hybrid models on sale in the United States, with one additional model, the Lexus LS 600h scheduled for launch in 2007. As can be seen in the chart above, the U.S. market contributes significantly to our global hybrid sales.

All auto manufacturers try to find the right combination of features, such as fuel economy, emissions, and power that customers value. No matter how brilliant or appealing a product may be, it will not succeed in the marketplace unless it is better in every respect than the product it seeks to replace. This is why Toyota's hybrid products reflect the customer preferences in each market segment in

which they compete. In all instances, with performance equalized, hybrids offer a superior combination of low emissions and higher fuel economy.

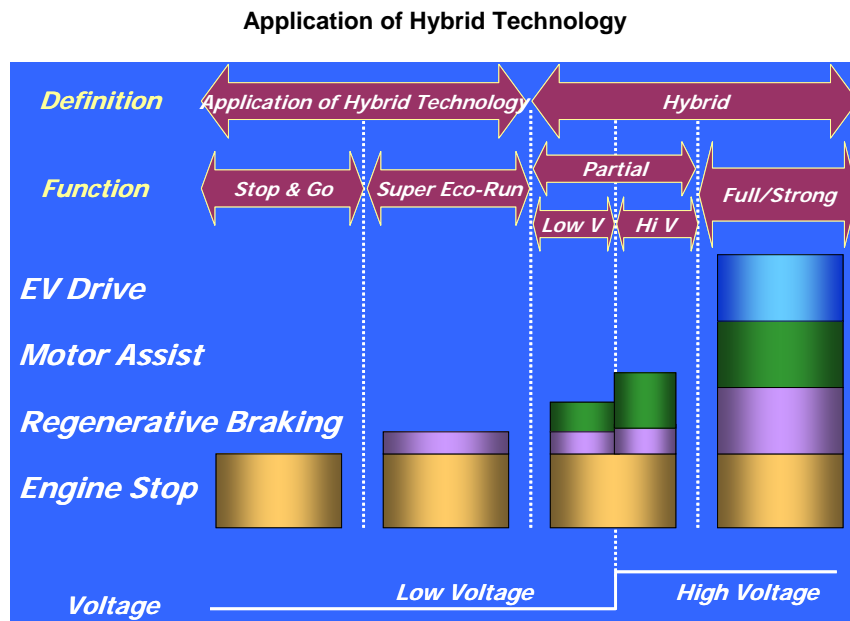
For instance, the Prius maximizes fuel economy, while achieving class average performance. The Lexus LS 600h will provide 12-cylinder performance and class leading V-8 fuel economy. And the 4-cylinder Camry Hybrid offers a combined EPA fuel economy label value of 39 mpg, while at the same time achieving 187 horsepower.

Importantly, hybrids are saving fuel today using existing infrastructure.

As more hybrid products enter the market, the balance between fuel economy, emissions and performance may shift and evolve over time as market forces change. Total cumulative sales by all manufacturers in the United States will soon exceed 500,000 units and further models are planned. In addition to the Toyota products that are already in the market or planned, 12 other models from other manufacturers are in the planning process or already on the market.

The application of hybrid technology takes different forms and not all offer the same range of benefits. Toyota's designs are known as a full or strong hybrid. This means the battery and power electronic components of our design are the primary influences on system efficiency and provide the benefits of motor assist and an all-electric vehicle (EV) range. We believe that as future technologies

are developed, the benefits of a strong hybrid approach will become even more pronounced.



Moving forward, we can easily see the results of Toyota's continuous development philosophy by examining the improvement in the Prius performance during the six years since it was launched.

**Prius History**

Model Years	1998-2000 *	2001-2003	2004-
City Label FE	43	52	60
Highway Label FE	41	45	51
Combined Label FE	42	48	55
0-60 Acceleration	14.5	12.5	10.1
Emissions	LEV	SULEV	AT-PZEV
Size Class	Subcompact	Compact	Midsize

\* Japan only

We have increased the combined label fuel economy of the Prius by over 30 percent, improved the 0-60 mph acceleration by 4.4 seconds, and steadily reduced the already low emissions. These enhancements are primarily the result



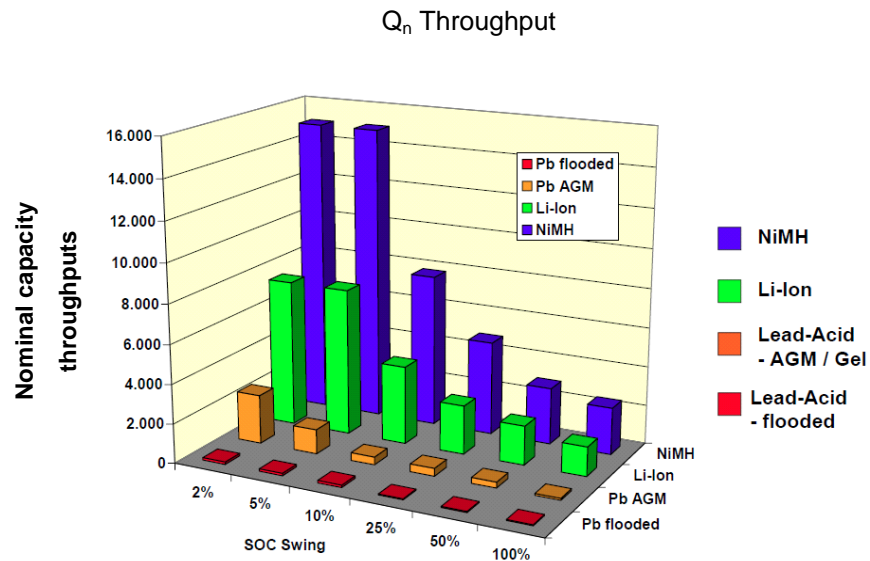
of reductions in weight and size of electrical components and steady improvement in battery technology.

As a direct result of this approach, we can foresee a time when we offer a hybrid in every segment in which we compete. Over time, the costs and complexity of hybrid systems may be improved to the point that a hybrid becomes a normal “check the box” powertrain option, just like four, six and eight cylinders are today. Under these conditions, it is reasonable to expect that Toyota’s global hybrid production could exceed 1 million units each year some time early in the next decade.

Particularly interesting is the continuing development of lithium-ion battery technology. We are hopeful this will lead to low-cost, light-weight batteries with high energy densities, providing the ability to increase the all-electric range and efficiency of hybrid products incorporating full or strong hybrid approaches.

## Plug-In Hybrids

We are, of course, aware of the enthusiasm in some quarters for plug-in-hybrid (PHEV) technology. The Prius, with its inherent advantages of a strong hybrid design, has been the candidate of choice for many early aftermarket conversions.



source: Christian Rosenkranz ( VARTA) "Plug-in Hybrid Batteries" EPRI workshop at EVS20

Among other promising technologies, Toyota is investigating the idea of PHEV designs. In the future, this type of approach may have merit. We believe that PHEV's ability to successfully compete in the market to a large extent depends on the development of battery technology that is lightweight, inexpensive and durable.

There are other challenges to be met in the development of PHEVs. Many current PHEV designs use deep charge/discharge cycles to improve their all electric range. As we can see from the above data, battery life is adversely impacted by large swings in the state-of-charge (SOC). Battery management systems in the Prius restrict SOC swings to a carefully defined level that is consistent with its very long battery life. Successful PHEV designs must carefully balance the desire for longer all-electric range with cost and weight targets and the need to extend the lifetime of the battery system.

## Hydrogen Fuel Cell

Our ultimate goal is to produce technologies that can eliminate vehicle emissions and greatly enhance energy security. That is the role of the hydrogen fuel cell and why Toyota considers it one of our key technologies for development. Fuel cell vehicles offer the promise of unparalleled operational efficiency, long driving range and a diversity of fuel sources. Although substantial progress is being made in developing this technology, the promises offered by a hydrogen economy must wait until sometime in the future to be fulfilled.

## Conclusion

In closing, we believe that as new technologies are considered, three conditions must be satisfied before they can successfully enter the market:

1. All technical challenges must be met. The end product must offer advantages not provided by the product it seeks to replace and the emerging technology must be competitive in all traditional areas of evaluation.
2. Society must be prepared. For alternative fuels this means, at a minimum, development of fuel production and delivery systems that proceed at pace with market driven introductions of advanced technology. In the case of

- grid connected technologies, this may mean the development of low carbon electrical generation plans. In every instance this requires education and outreach programs that inform and prepare consumers.
3. Market conditions that signal to consumers the movement to alternative technology is real and enduring.

Unless all of the conditions listed above are met, it is unlikely that any new technology can successfully replace its traditional competitor.

With regard to our transportation systems, the next few years will be challenging as new technologies and fuels begin to make substantial inroads into traditional markets. The challenges of geopolitics, energy security and environmental awareness will broadly impact this situation. Toyota strongly believes that our hybrid technology provides the fundamental basis necessary to capitalize on the various promises that are being offered.



## HYBRID VEHICLE STORY



- Toyota introduced the world's first mass-market gas-electric hybrid vehicle in Japan in 1997
- Since 2000, Toyota has sold more than 300,000 hybrids in the U.S.
- Combined, all the hybrids Toyota has sold in the U.S. have saved more than 133 million gallons of gas
- In 2006, Lexus will introduce the GS 450h hybrid luxury sports sedan and Toyota will introduce the Camry Hybrid
- By early next decade, one quarter of the vehicles Toyota sells in the U.S. will be hybrids
- Worldwide, Toyota plans to sell a million hybrids a year by early next decade
- In 2006, Toyota will sell approximately 200,000 hybrid vehicles in the U.S.



- **Toyota Prius** was first introduced in the U.S. in 2000
- Now the most popular hybrid in the U.S. and the world
- More than 250,000 sold in the U.S. since 2000
- For 2006, Toyota will sell about 110,000 Prius in the U.S.
- 80 percent cleaner for smog-forming emissions
- AT-PZEV (advanced technology partial zero emission vehicle)
- EPA Fuel Mileage Estimates: 60 city/51 hwy/55 combined
- MSRP: \$21,725
- Federal tax credit: \$3,150

- Introduced in April 2005
- **Lexus RX 400h** is the world's first luxury hybrid vehicle
- Provides V8 performance but saves gas and has fewer emissions
- 80 percent cleaner for smog-forming emissions
- SULEV (super ultra low emissions vehicle)
- EPA Fuel Mileage Estimates: 31 city/27 hwy (AWD model)
- MSRP: \$49,060 (AWD model) • Federal tax credit: \$2,200



- **Highlander Hybrid** introduced in June 2005
- Offers convenience of an SUV, but with superior power and fuel mileage
- 80 percent cleaner for smog-forming emissions
- SULEV emissions rating
- EPA Fuel Mileage Estimates: 31 city/27 hwy (AWD model)
- MSRP: \$33,030 (2WD model)
- Federal tax credit: \$2,600



## HYBRID VEHICLE STORY



- Toyota is putting Hybrid Synergy Drive in America's most popular car
- **Camry Hybrid** will go on sale in the spring and production in Kentucky will begin in summer
- For 2006, Toyota will sell approximately 30,000
- 80 percent cleaner for smog-forming emissions
- AT-PZEV rated like the Prius
- EPA Fuel Mileage Estimates: 40 city /38 hwy /39 combined
- MSRP: \$25,900
- Federal tax credit: \$2,600

- **Lexus GS 450h** will be the world's first front-engine, rear-wheel drive full hybrid
- On sale April 2006
- Provides V8 performance but saves gas and has fewer emissions
- 67 percent cleaner for smog-forming emissions, 30 percent more fuel efficient
- Zero to sixty acceleration is 5.2 seconds
- EPA Fuel Mileage Estimates: 25 city/28 hwy / 26 combined
- MSRP: \$54,900
- Federal tax credit: \$1,550



- **2008 Lexus LS 600h L** debuted at the 2006 New York Auto Show
- Introduced Lexus Hybrid Drive system
- On sale in April 2007
- World's first full V8 hybrid
- The 5.0-liter engine with large high-output motors will generate more than 430 hp.
- Power and performance on par with 12-cylinder premium luxury sedans with fuel efficiency that will be best in V-8 class
- SULEV rated – 70 percent cleaner than its cleanest competitors
- In addition to performance and environmental benefits, will set a new standard in noise, vibration and harshness (NVH) standards